

[54] POWERED SLIDING DOOR OPENER/CLOSER FOR VEHICLES

[75] Inventors: James G. Boyko, Gorham; Timothy J. Farrar, Buxton; Stephen B. Peterson, Cape Elizabeth, all of Me.

[73] Assignee: Masco Industries, Inc., Taylor, Mich.

[21] Appl. No.: 189,242

[22] Filed: May 2, 1988

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 135,133, Dec. 18, 1987.

[51] Int. Cl.⁴ E05D 15/10; E05F 15/00

[52] U.S. Cl. 49/213; 49/214; 49/280

[58] Field of Search 49/213, 214, 215, 209, 49/360, 279, 280, 289, 210

References Cited

U.S. PATENT DOCUMENTS

689,767	12/1901	Ware et al.	49/289
4,462,185	7/1984	Shibuki et al.	49/280 X
4,549,369	10/1985	Foley, Jr.	49/280 X
4,612,729	9/1986	Sato	49/280 X
4,617,757	10/1986	Kagiyama et al.	49/213 X
4,640,050	2/1987	Yamagishi et al.	49/213 X
4,644,692	2/1987	Schindehutte	49/213

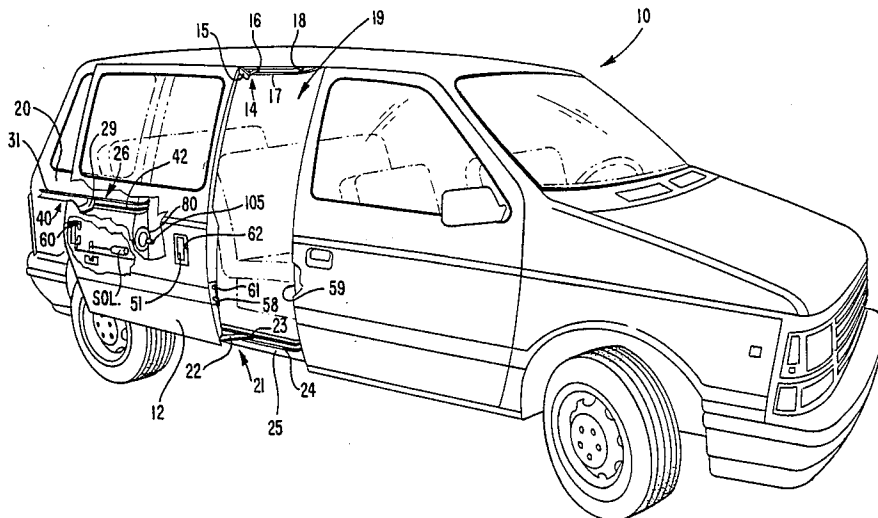
Primary Examiner—Philip C. Kannan

Attorney, Agent, or Firm—Lerner, David, Littenberg, Krumholz & Mentlik

[57] ABSTRACT

A door operator for a slide door that is slidingly supported relative to a door opening in a side panel of a vehicle body is disclosed. The door is supported adjacent its forward end on at least one forward guide member and is supported adjacent its rear end on a rear guide member. The guide members guide the door through (i) an initial closing movement generally parallel to the side panel, (ii) a final closing movement generally parallel to the side panel, (iii) at least a portion of its final closing movement generally toward the plane of the door opening, and (iv) at least a portion of its initial opening movement generally away from the plane of the door opening. The door operator comprises means including a first cable member coupled to the rear end of the door and a second cable member coupled to the forward end of the door for driving the door along the guide members to thereby move the door through its initial and final opening and closing movements. When used as part of a system, the powered sliding door operating system also includes a clamping means including a rotatable striker plate mounted on the vehicle body and having an eccentrically mounted striker pin thereon engagable by a latch bolt member on the door for clamping the door to the vehicle body with the door in a finally closed position in the door opening.

18 Claims, 12 Drawing Sheets



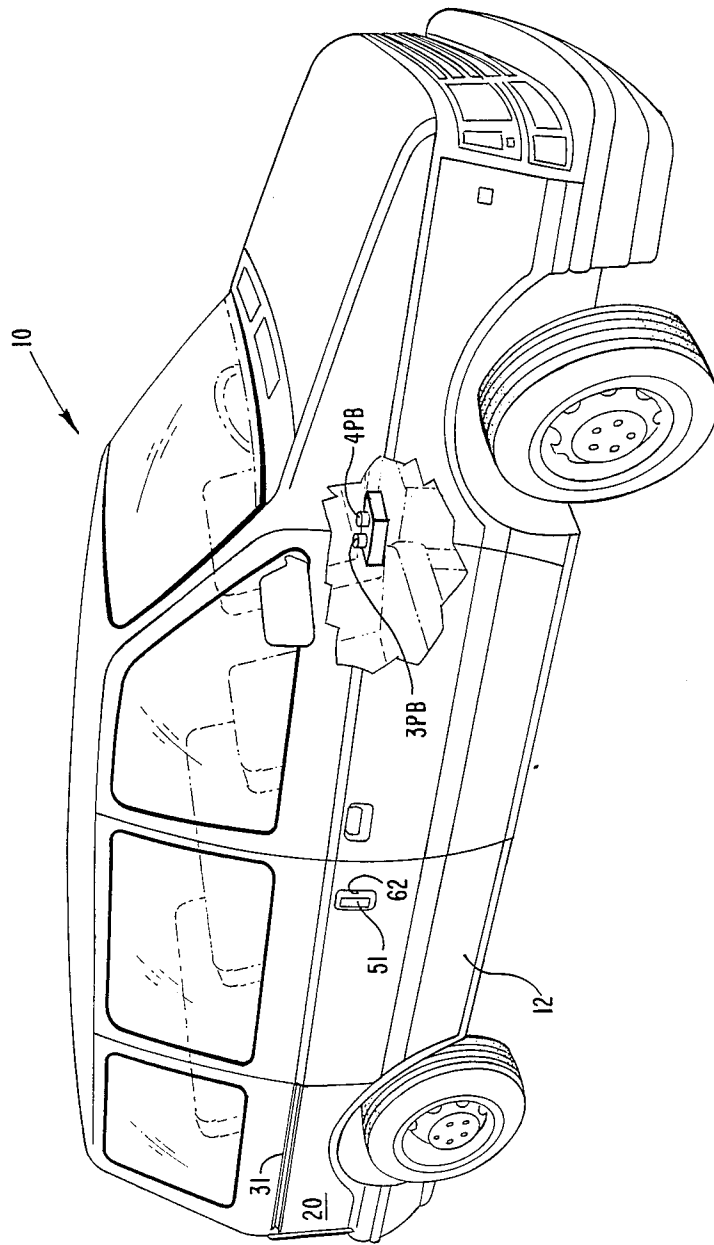


FIG. 1

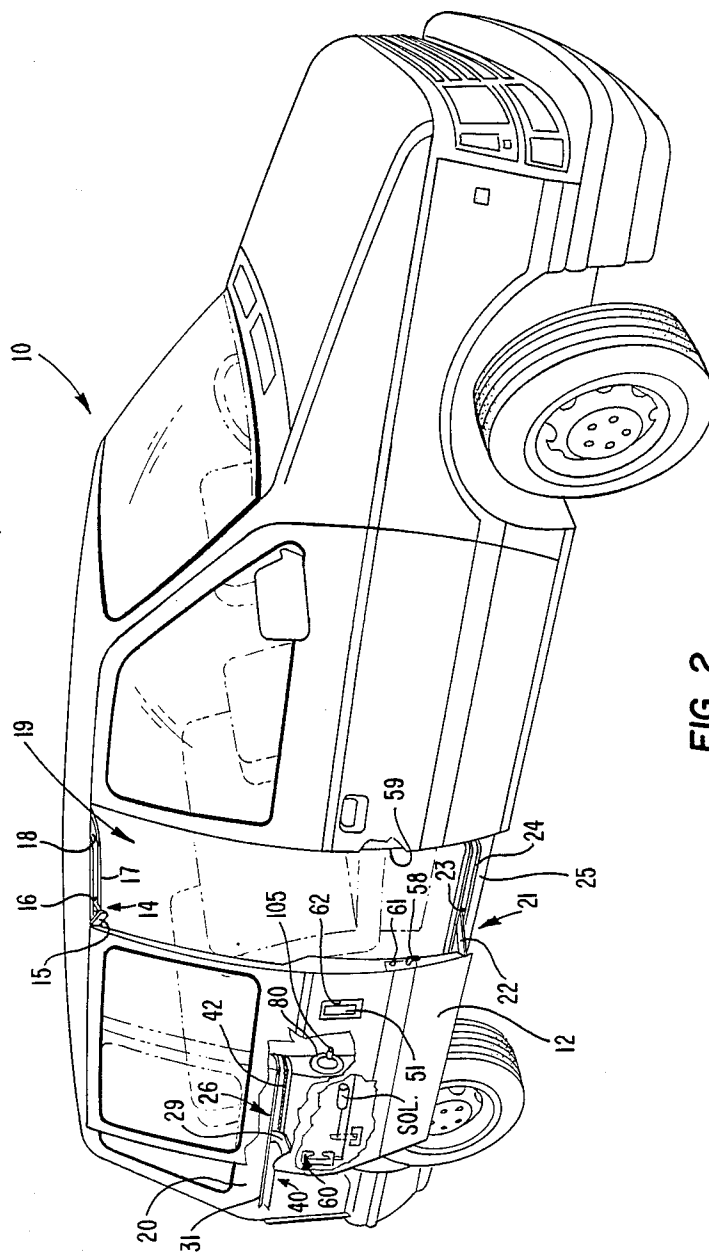


FIG. 2

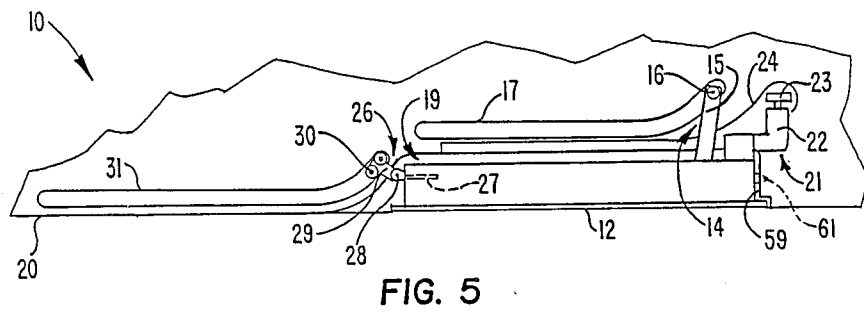
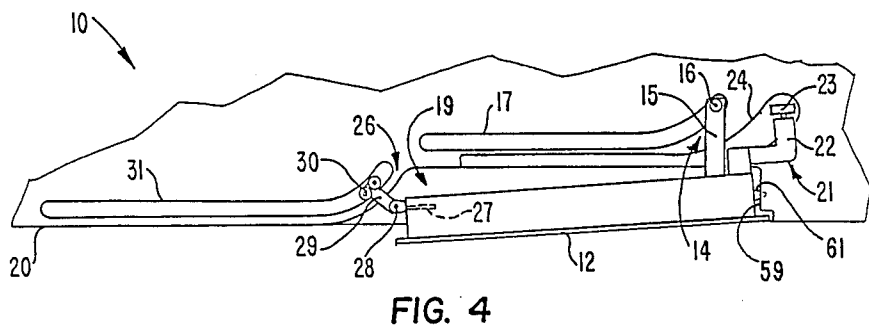
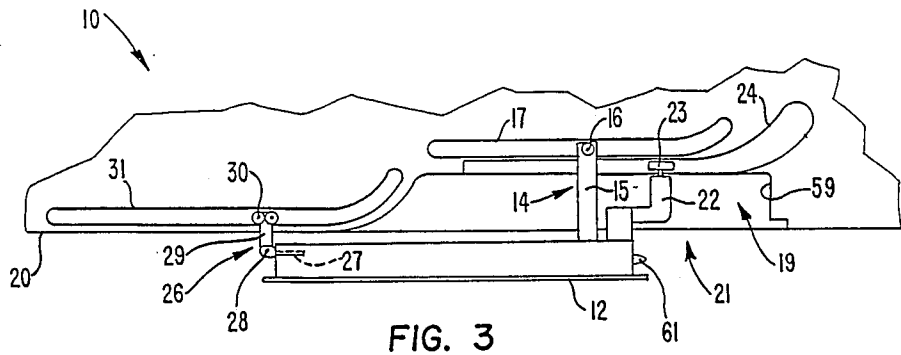
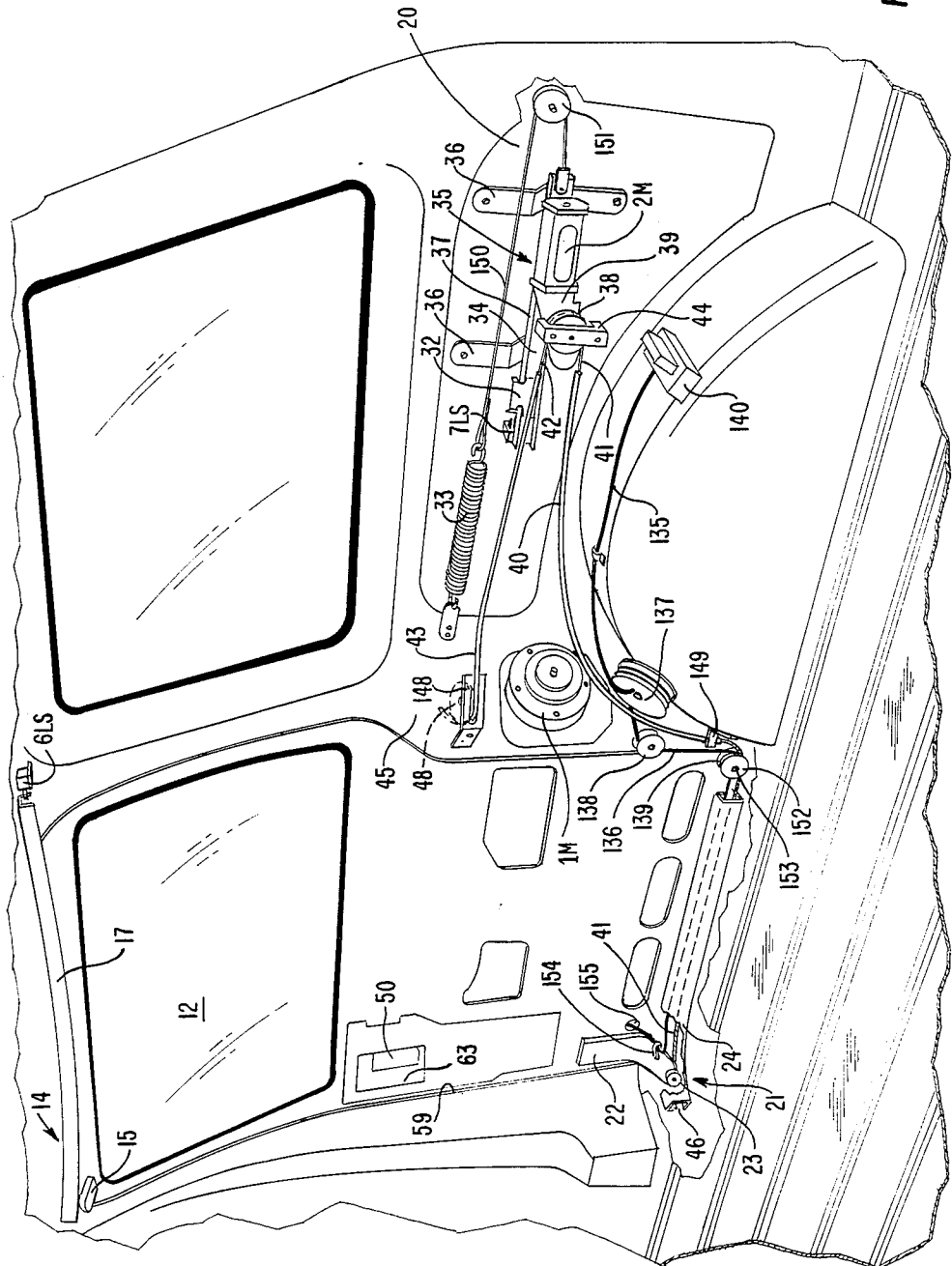


FIG. 6



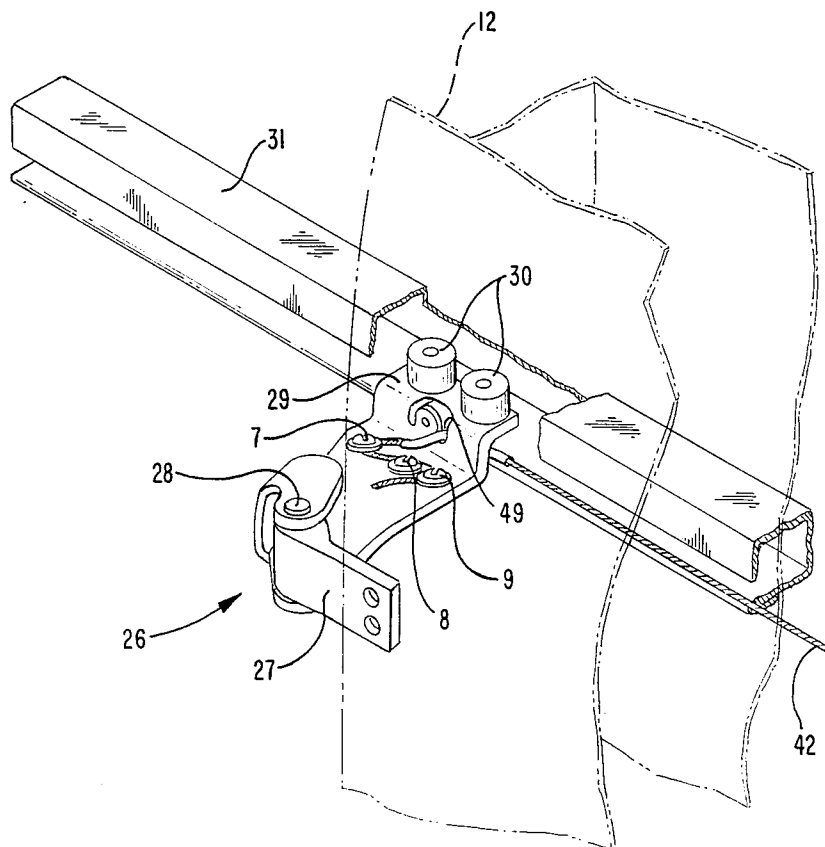
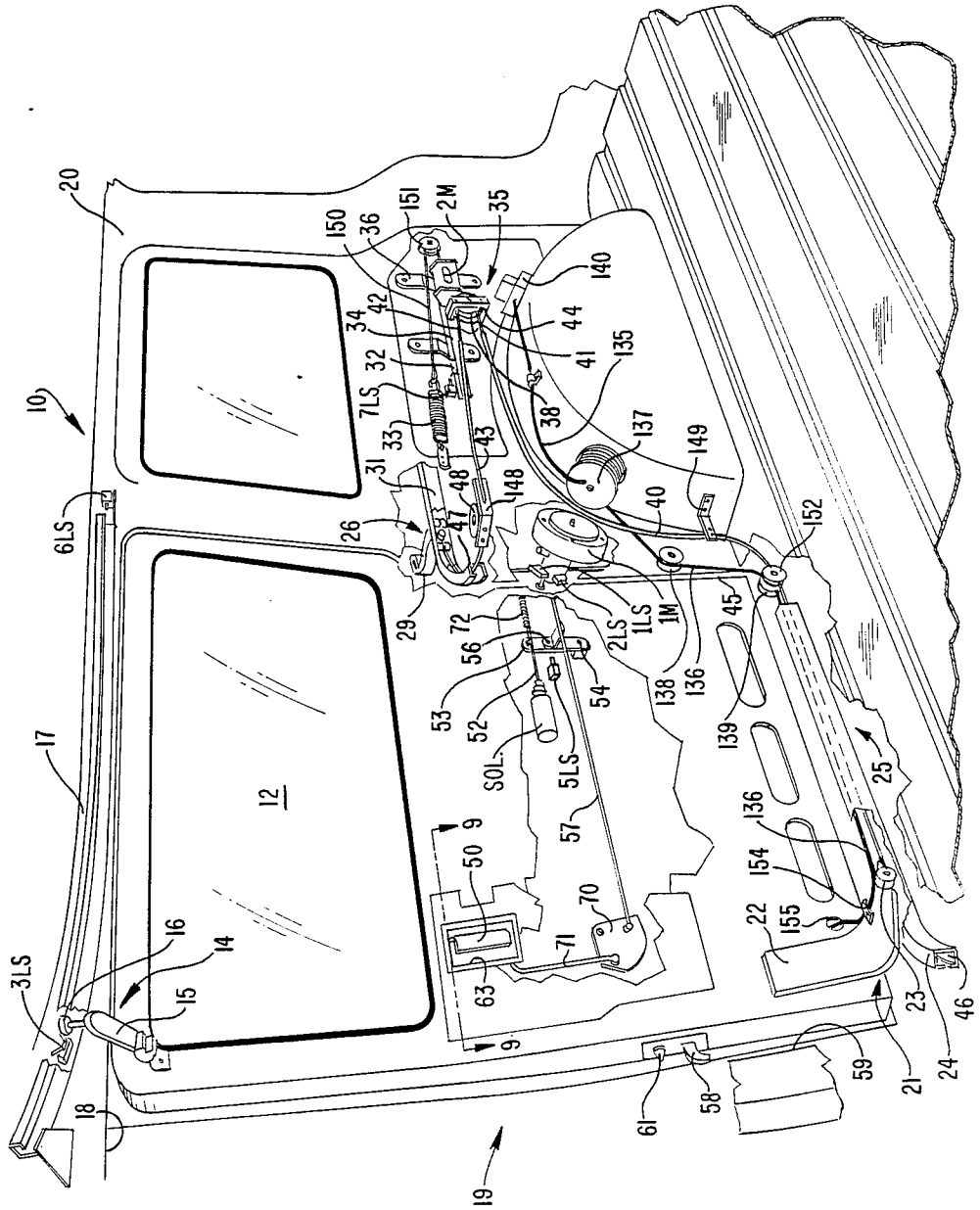


FIG. 7

FIG. 8



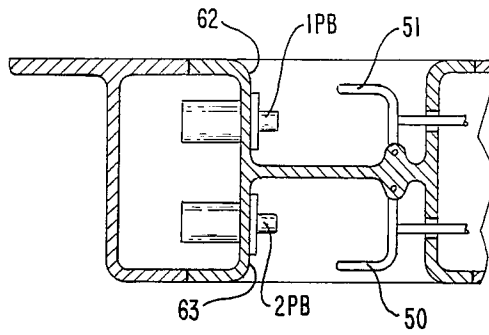


FIG. 9

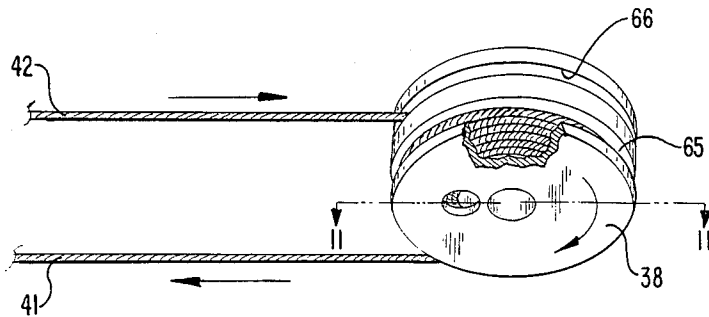


FIG. 10

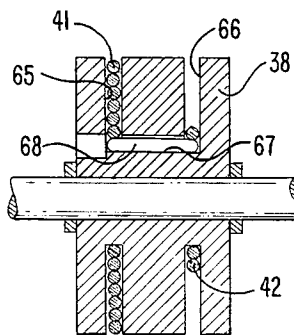


FIG. 11

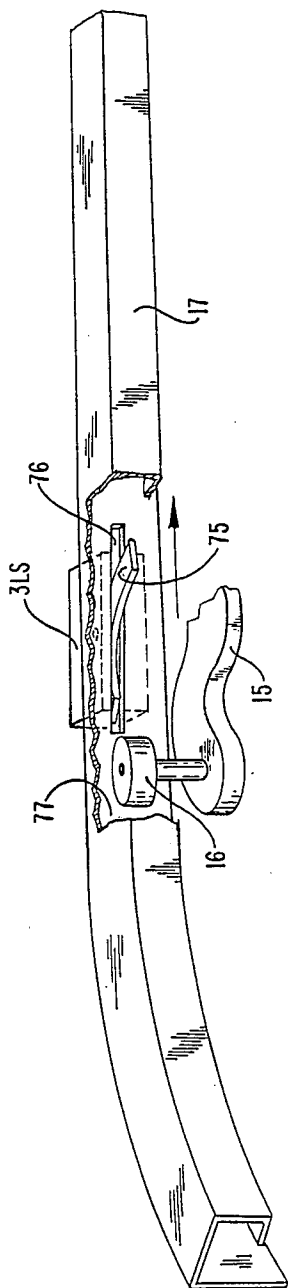


FIG. 12A

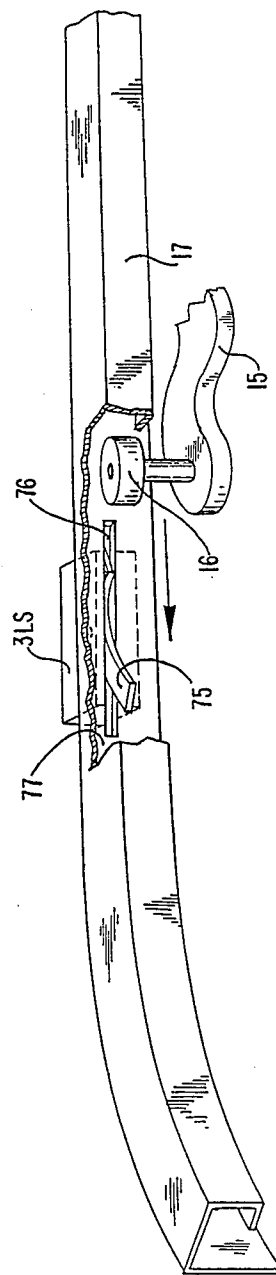
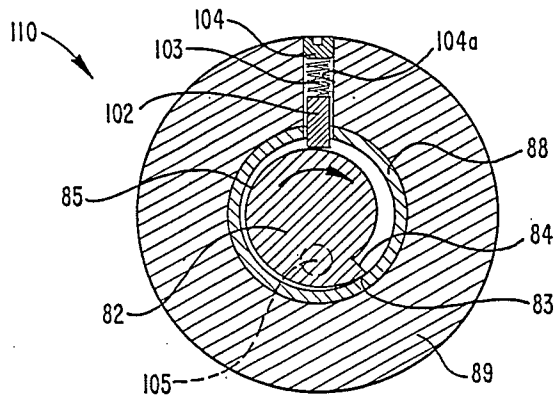
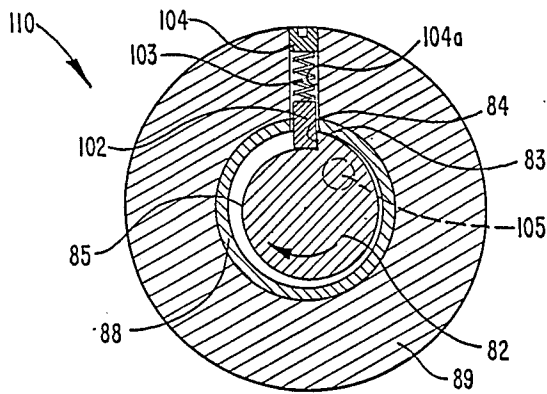
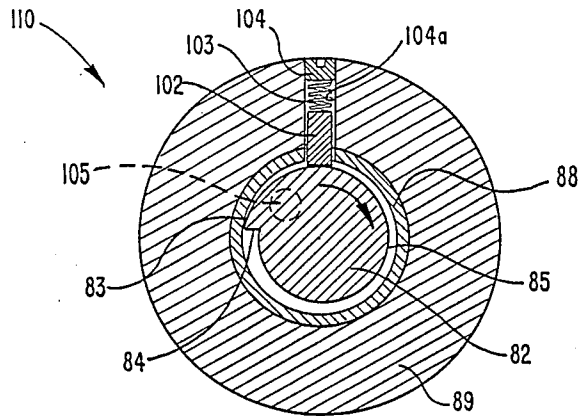


FIG. 12B



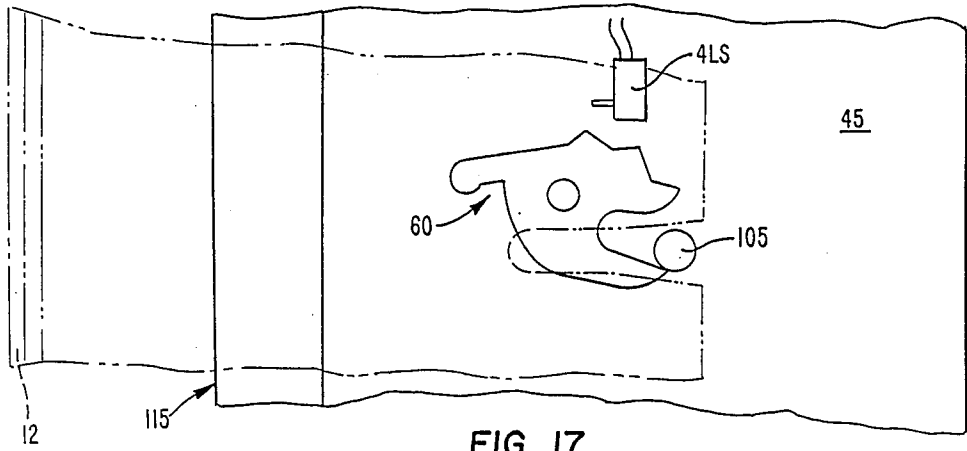


FIG. 17

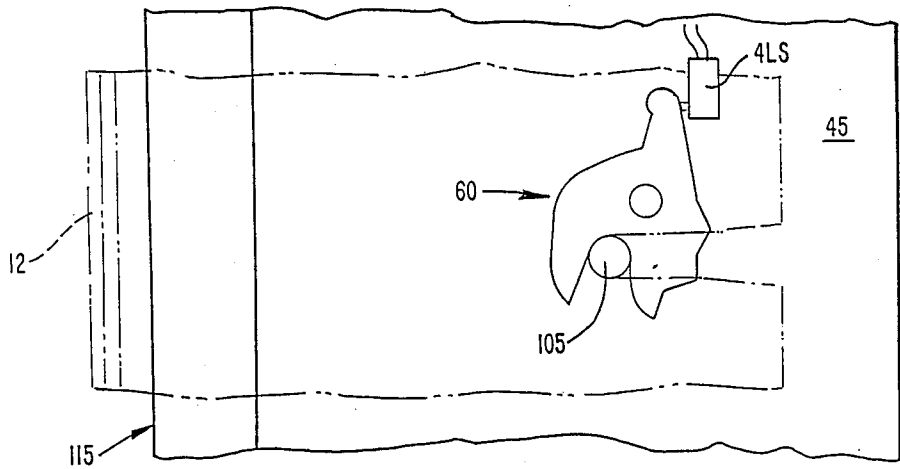


FIG. 18

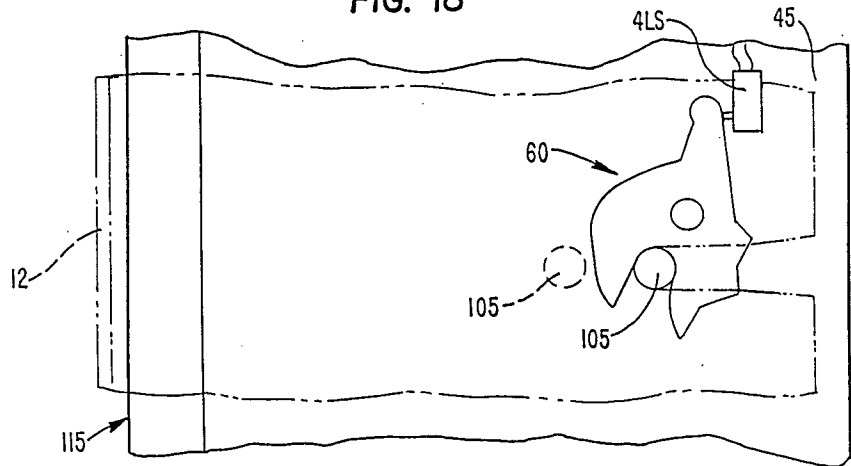
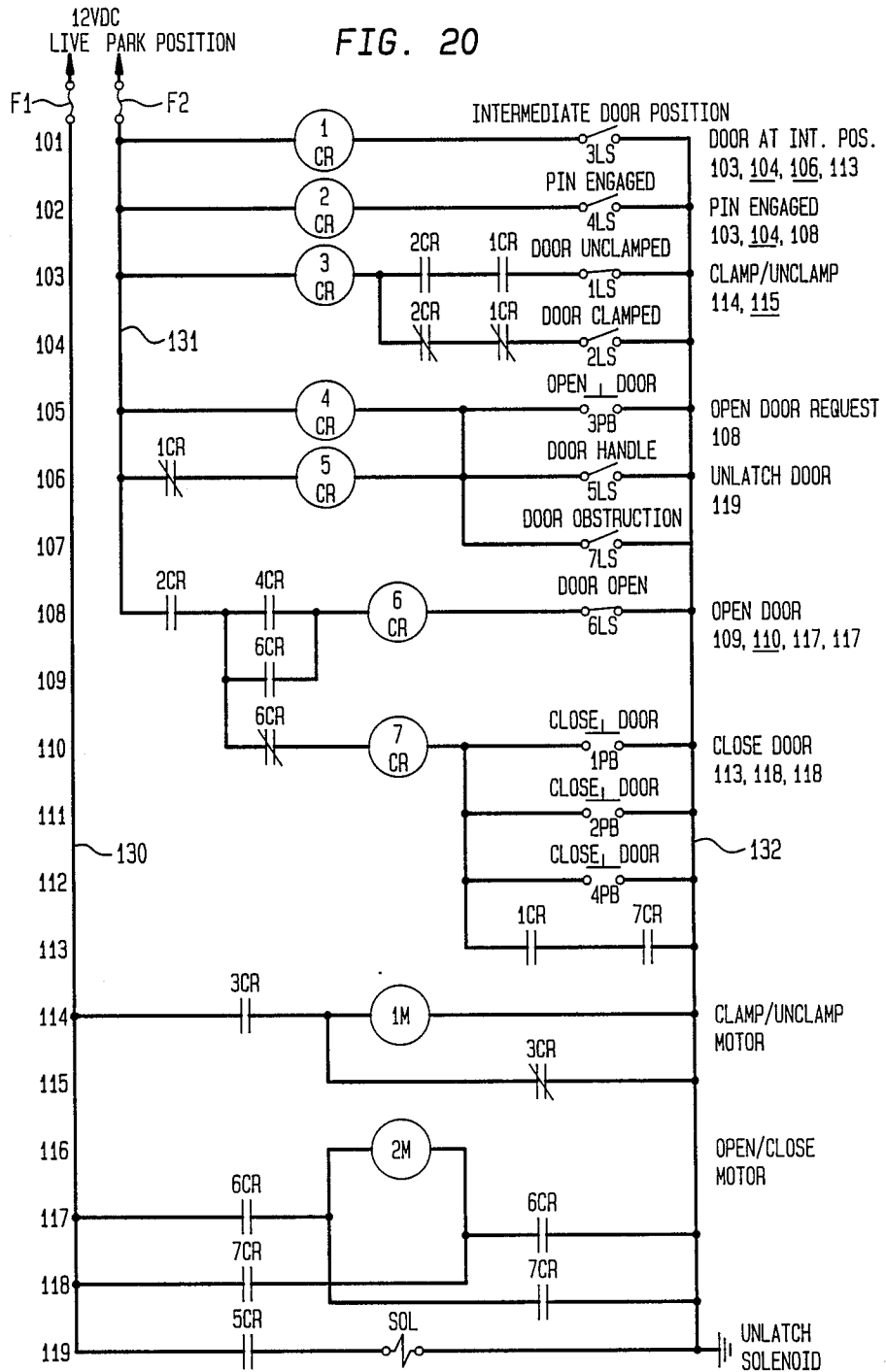


FIG. 19

FIG. 20



**POWERED SLIDING DOOR OPENER/CLOSER
FOR VEHICLES**

**CROSS REFERENCE TO RELATED
APPLICATION**

This application is a continuation-in-part of application Ser. No. 135,133, filed Dec. 18, 1987.

BACKGROUND OF THE INVENTION

This invention relates to powered sliding door operating systems for vehicles and, more particularly, to powered sliding door operating systems for van type vehicles having a door opening in a side wall of the van, wherein the sliding door is moved generally parallel to the van side wall during its initial closing movement and for a major portion of its full closing movement, as well as during a major portion of its full opening movement, including its final opening movement, and wherein the sliding door move generally toward and generally away from the plane of the door opening in its respective final closing and initial opening movements, so as to be flush with the side wall when fully closed and to be alongside of and parallel to the side wall, to the rear of the door opening, when fully opened.

In sliding door systems of the foregoing type, upper and lower forward guide rails are attached to the top and bottom portions, respectively, of the door opening, and a rear guide rail is attached to the exterior of the side wall, at an elevation that is approximately midway between the elevation of the upper and lower forward guide rails. The respective forward end portions of the various guide rails are curved inwardly of the body of the van, and bracket and roller assemblies fastened to the respective upper and lower forward ends of the sliding door and to an intermediate position at the rear end of the sliding door are slidably supported in the guide rails to guide the door through its opening and closing movements.

The various portions of the movements that sliding doors of vans undergo during opening and closing thereof have different power requirements. Thus, the initial door closing movement and a major portion of the door closing movement that follows it is a high displacement/low force traversing movement, during which little force is required to achieve large movements of the door since only frictional resistance and grade-caused resistance, if any, must be overcome. Similarly, the final opening movement and a major portion of the opening movement which precedes it is a high displacement/low force traversing movement for the same reasons. On the other hand, the final closing movement of the door is a low displacement/high force motion, since at this time an elastomeric weather seal which surrounds the door opening must be compressed and, also, an unlatched latch bolt member carried at the rear end of the door must engage and be rotated to a latched position by a striker pin carried by the van body at the rear end of the door opening.

In manually operated sliding door units for van type vehicles the sliding door is typically moved with great momentum through its closing movement in order to insure that it will fully compress the weather seal strip at the end of such movement and, also, that the latch bolt member will be rotated to its latched position in engagement with the striker pin at such time. Such high momentum movement of the sliding door member presents a significant safety problem with respect to vehicle

occupants, who may inadvertently have failed to remove portions of their body from the path of movement of the sliding door.

Various attempts have heretofore been made to mechanize or power the opening and closing movements of sliding doors of van type vehicles. One such attempt is illustrated in U.S. Pat. No. 4,612,729 to Sato. In the Sato patent a motor driven pinion carried by the lower front bracket and roller assembly of the door cooperates with a rack gear carried by the lower front guide rail in the door opening to move the door between its fully open and fully closed positions. In this arrangement, as in the case of the manually operated door discussed above, the rear of the door completes its closure due to a high momentum imparted to it during its closing movement and, therefore, the safety hazard discussed above is not overcome.

Similarly, U.S. Pat. No. 4,617,757 to Kagiya et al and No. 4,640,050 to Yamagishi et al represent additional attempts to mechanize the opening and closing movements of van doors. They employ cable drives which are coupled to the lower front bracket and roller assemblies of the doors to move the doors through their opening and closing movements. Here, again, the systems rely on momentum to complete the door closing movements and, thus, do not satisfactorily meet the safety problems that attend such high momentum closing movements.

U.S. Pat. No. 4,462,185 to Shibuki et al represents yet another patent relating to mechanizing the movement of van doors. In this case a friction wheel engages the bottom portion of the door and is employed to drive the door through the major portions of its opening and closing movements parallel to the side wall of the van. In addition a pair of turntable arms pivotably connected end-to-end between the friction wheel and the floor of the door opening is utilized to draw the rear of the door inward against the compression forces of the weather seal strip. While this prior art design presumably operates with lower momentum forces generated during the closing movement than those discussed above, it employs a complicated, costly mechanism which is difficult to originally install and difficult to repair in the event of a breakdown. Moreover, it would be difficult, at best, to retrofit the mechanism shown in this patent to a van type vehicle that was not originally designed to receive it.

In addition to the foregoing prior art attempts to mechanize or power the opening and closing movements of sliding doors of van type vehicles, final closing devices or clamping mechanisms for powering the final low displacement/high force movement of sliding van doors are in current development by the assignee of the present application. Two such low displacement/high force final closing or clamping mechanisms have been shown and described in the co-pending applications of James G. Boyko, Ser. No. 100,940, filed Sept. 25, 1987 and James G. Boyko et al, Ser. No. 119,824, filed Nov. 12, 1987, which applications are assigned to the assignee of the present application. The disclosures of the aforesaid two applications are incorporated by reference into the present application. In each of said co-pending applications a final closing device or clamping mechanism for the sliding door of a van type vehicle is disclosed. In each case the door includes a latch bolt member movable between latched and unlatched positions, and a handle or a lock member movable between open and

closed positions. The final closing device or clamping mechanism in each case includes a striker support plate that is mounted on the vehicle body at the rear end of the opening for the sliding door for rotational movement about an axis perpendicular to such plate; a striker pin carried by the striker support plate and projecting therefrom at a position eccentrically offset from the axis; and, means carried by the vehicle body and connected to the striker support plate for rotating the striker support plate. The striker pin is movable between an extended and a retracted position upon rotation of the striker support plate so that when the striker pin is engaged by the latch member bolt the striker support plate is rotated, the sliding door is moved between a partially open position away from the door opening in the vehicle body to a fully closed position in sealing engagement therewith. The later co-pending application in addition to disclosing the foregoing structure includes a crash worthiness feature therein that adds a pawl and ratchet mechanism to the striker support plate rotating means to prevent the rotating means from being reversely rotated in the event high door opening forces are applied to the door from the inside of the vehicle during an accident.

Although the final closing devices or clamping mechanisms of the aforesaid co-pending applications provided excellent final closing operations for sliding van doors, they did not include provisions therein for powering the sliding van doors through the major portions of their opening and closing movements, nor did they include provisions therein for powering the sliding van doors during the late closing movements thereof, to the point where the latch bolt mechanisms of the sliding van doors engage with and close about the striker pins of the clamping mechanisms.

An improved powered sliding door operator and system for van type vehicles having provisions therein (i) for powering the sliding van doors through the major portions of their opening and closing movements, (ii) for powering the sliding van doors during the late closing movements thereof to engage the latch bolt mechanisms of the sliding van doors with the striker pins of the final clamping mechanisms, and (iii) for finally clamping the sliding van doors to a fully closed position, has also been developed by the assignee of the present application. Such powered sliding door operator and system for van type vehicles has been shown and described in the co-pending application of James G. Boyko, Timothy J. Farrar and Stephen B. Peterson, Ser. No. 135,133, filed Dec. 18, 1987, which application is assigned to the assignee of the present application. In said co-pending application Ser. No. 135,133, the disclosure of which is hereby incorporated by reference into the present application, there is provided a door operating system for a door that is slidably supported relative to a door opening in a side panel of a vehicle body. The door is supported adjacent its forward end by forward brackets slidable in upper and lower forward guide members carried by the vehicle body, and is supported adjacent its rear end by a rear bracket that is slidable in a mid-level rear guide member carried on the outside of a side panel of the vehicle. Partially exposed, motor driven cable members attached to the rear bracket and supported adjacent opposite ends of the rear guide member are employed to move the door through its opening movement, through its initial closing movement and through an initial portion of its final closing movement. The final portion of its closing movement is accom-

plished using a final clamping mechanism of the type disclosed in said co-pending Application Ser. No. 119,824.

Although the powered sliding door system of said copending application Ser. No. 135,133 provides for excellent low momentum operation of sliding van doors, thereby significantly decreasing the safety risk associated with the mechanization of such doors, the partially exposed motor-driven cable members employed in moving the sliding doors still represent a potential, albeit reduced, source of injury to users of the system.

It is, therefore, a primary object of the present invention to provide an improved powered sliding door operator and system for van type vehicles in which the sliding door is moved with low momentum from its fully open position to its nearly closed position, and vice versa, so as to reduce the safety hazards encountered in existing manual sliding doors and existing powered sliding door operators and systems.

Another object of the present invention is to provide a powered sliding door operating system for completely closing the sliding door in a slow controlled manner that obviates the safety hazard involved in closing sliding doors using exposed cable members according to existing door designs.

It is yet another object of this invention to provide an improved powered sliding door operator and system in which the manual effort required to open and close the sliding door is substantially reduced or eliminated.

A still further object of this invention is to provide for improved near-normal manual operation of the sliding door in the event the powered sliding door operating system is not functional due to a vehicle accident, system failure, or the like.

An additional object of the present invention is to provide an improved powered sliding door operating system for van type vehicles which can be actuated either from the vehicle driver's seat or from the sliding door itself.

Further objects and advantages of this invention will become apparent as the following description proceeds.

SUMMARY OF THE INVENTION

Briefly stated and in accordance with one embodiment of this invention, there is provided a door operator for a slide door that is slidably supported relative to a door opening in a side panel of a vehicle body. The door is supported adjacent its forward end by at least one forward bracket that is slidable in a forward guide member and is supported adjacent its rear end by a rear bracket that is slidable in a rear guide member. The guide members guide the door through (i) an initial closing movement generally parallel to the side panel, (ii) a final opening movement generally parallel to the side panel, (iii) at least a portion of its final closing movement generally toward the plane of the door opening, and (iv) at least a portion of its initial opening movement generally away from the plane of the door opening. The door operator comprises means including cable members coupled to the forward and rear ends of the door for driving the door along the guide members to thereby move the door through its initial and final opening and closing movements.

In accordance with another aspect of the invention there is provided an improved door operating system for a door that is slidably supported relative to a door opening in a side panel of a vehicle body. The door is

supported adjacent its forward end by at least one forward bracket slidable in a forward guide member carried by the vehicle body and is supported adjacent its rear end by a rear bracket that is slidable in a rear guide member carried by the vehicle body. The guide members guide the door through (i) an initial closing movement generally parallel to the side panel, (ii) a final opening movement generally parallel to the side panel, (iii) at least a portion of its final closing movement generally toward the plane of the door opening, and (iv) at least a portion of its initial opening movement generally away from the plane of the door opening. The door includes a latch bolt member carried adjacent the rear end thereof and movable between latched and unlatched positions. The door operating system comprises a drive means that includes two cable members, one of which is coupled to the rear end of the door and the other of which is coupled to the forward end of the door, for moving the door along the guide members and through the initial and final opening and closing movements, and a clamping means that includes a rotatable striker plate mounted on the vehicle body and having an eccentrically mounted striker pin thereon engageable by the latch bolt member of the door for clamping the door to the vehicle body with the door in a finally closed position in the door opening.

BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter regarded as the invention herein, it is believed that the present invention will be more readily understood from the following description, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view, with parts broken away for clarity, of a van type vehicle having a powered sliding door operating system therein in accordance with the present invention;

FIG. 2 is a view similar to FIG. 1, with parts broken away for clarity, showing the sliding door of the van in a partially open position;

FIG. 3, 4, and 5 are diagrammatic views, illustrating the path of movement followed by the sliding door relative to its supporting guide rails during closing of the door;

FIG. 6 is a perspective view of the interior of the van shown in FIGS. 1 and 2, with parts cut away for clarity, illustrating an embodiment of this invention in which a cable member having one of its ends coupled to the forward end of the sliding door and the other of its ends coupled to the rear end of the sliding door is driven by a drive motor that is slidably mounted on a side wall of the van;

FIG. 7 is an enlarged detailed perspective view of a portion of the cable member and sliding door illustrated in FIG. 6, showing the manner in which the cable member is fastened to a rear bracket and roller assembly carried at the rear end of the door;

FIG. 8 is a perspective view of the interior of the van, similar to that of FIG. 6, but viewed from a different point inside of the vehicle and showing the door in a partially open position;

FIG. 9 is a sectional view, taken along the line 9—9 of FIG. 8, showing the locations of push button switches that are used in controlling the closing of the sliding door;

FIG. 10 is a fragmentary perspective view of a two-groove drive pulley employed in this invention, show-

ing cable conditions that are extant during a door closing movement;

FIG. 11 is a sectional view of the two-groove drive pulley, taken along the line 11—11 of FIG. 10;

FIGS. 12A and 12B are fragmentary perspective views of a limit switch, positioned in the upper forward guide of the sliding door, which is actuated and deactivated when the door reaches a predetermined intermediate point during its movement between its fully opened and closed positions;

FIG. 13 is an exploded perspective view of a final closure means or clamping mechanism that is employed to move the nearly closed sliding door to its fully closed position against the compression resisting forces exerted by the weather seal strip of the door;

FIGS. 14, 15 and 16 are enlarged sectional views, taken through a mechanism in FIG. 13 for precluding reverse rotation of the striker plate, and showing the relationship of a pawl to a single tooth ratchet wheel thereof when the striker pin is in its extended position, its retracted position, and enroute from its retracted position to its extended position, respectively;

FIGS. 17, 18 and 19 are diagrammatic elevation views, taken through the latch bolt mechanism of the door and the final closing mechanism on the door frame, showing the relationship of the latch bolt member and striker pin to the weather seal strip on the vehicle body during various stages of closing of the door; and,

FIG. 20 is a circuit diagram of an electrical system that may be employed in controlling the operation of the powered sliding door operating system.

DETAILED DESCRIPTION

Referring to the figures, wherein the invention has been illustrated on a van type of vehicle 10, the powered door operator and door operating system of the invention is used to open and close a sliding door 12 of the van. The sliding door 12 is supported on the body of van 10 at three points. The first point of support comprises a forward upper bracket and roller assembly, shown generally at 14 (FIGS. 2 and 8), that includes an arm 15, one end of which is fastened to the upper forward end of door 12 and the other end of which carries one or more rollers 16 on its upper surface. Rollers 16 engage and ride in a curved upper forward guide rail or member 17 that is fixedly carried on the lower surface of a vehicle body member 18 that surrounds a door opening, shown generally at 19, formed in a side wall 20 of the van.

The second point of attachment comprises a forward lower bracket and roller assembly, shown generally at 21, which includes an arm 22 having one of its ends fixedly attached to the lower forward end of door 12 and one or more rollers 23 carried at the other of its ends. The rollers 23 engage and ride in a curved lower forward guide rail or member 24 that is attached to a vehicle body member 25 that surrounds the lower portion of the door opening 19.

The third point of attachment comprises a rear, mid-level, bracket and roller assembly, shown generally at 26, which includes an arm 27 (FIG. 7) that has one of its ends fixedly attached to the rear end of door 12 and is pivotally attached at the other of its ends 28 to one end of a link 29. The other end of link 29 carries a plurality of rollers 30. The rollers 30 engage and ride in a curved rear guide rail or member 31 that is carried on the outside of side wall 20, at an intermediate level approxi-

mately midway between the levels of the upper and lower guide rails 17 and 24, respectively. The guide members 17, 24 and 31 curve toward the inside of the van 10 adjacent their forward ends.

The foregoing three points of support allow the slide door 12 to be slidably moved to and fro along the guide members 17, 24 and 31, with the door being guided by the guide members through an initial closing movement and a final opening movement that is generally parallel to the side wall 20 of the van, as shown in FIG. 3, and through final closing and initial opening movements that are respectively generally toward and away from the plane of the door opening, as shown in FIGS. 4 and 5.

Referring to FIG. 3, the fully open position of door 12 occurs when the door is moved fully to the left, or rear, relative to the guide members 17, 24 and 31, at which time the rollers 16, 23 and 30 are at the rear ends to their respective guide members 17, 24 and 31. When the door 12 is then moved to the right, or forward, its movement relative to the side wall 20 is essentially parallel to the side wall for a major portion of its traversing movement towards the door opening 19. As the door approaches the right hand ends of the various guide members 17, 24 and 31, the curved portions of guide members 17 and 24 are initially encountered by the corresponding rollers 16 and 23 so that the forward end of door 12 moves inwardly toward the door opening 19 somewhat prior to the time that the rear end of the door 12 starts moving inwardly. Thus, the forward end of the door 12 engages the weather seal strip in the door frame before the rear end of the door does and a pivoting action of the door then occurs, as may be seen by comparing FIG. 4 with FIG. 5. As the rollers 30 of the rear bracket and roller assembly 26 move through the inwardly curved forward end portion of guide member 31, the final closing movement of door 12 is accompanied by movement of the rear portion of the door into the door opening 19, as shown in FIG. 5.

Referring now more particularly to FIGS. 6-8, 10 and 11, a powered door operator, shown generally at 35, which is employed in moving the sliding door through its initial and final opening and closing movements, has there been illustrated. The door operator 35 includes a cable drive motor 2M carried by a tensioning slide assembly 34. Assembly 34 is mounted in a guide 37 that is fastened to the inside of side wall 20 via brackets 36. Motor 2M, when energized, rotates a drive pulley 38 through a clutch mechanism (not shown) that is coupled to the motor's gearing and output shaft (not shown) When the clutch mechanism is de-energized, as in an electrical system failure, the motor and its associated gearing are disconnected from the drive pulley, allowing manual operation of the door. Alternatively, an unclutched, high efficiency, back-driveable spur gear drive (not shown) may be employed to rotate drive pulley 38, yet allow manual operation of the door in the event of a system failure. In the embodiment shown, drive pulley 38 is supported on a bracket 39 that is fastened to motor 2M for sliding movement with the motor and the tensioning slide assembly 34.

A lower flexible sheath or conduit 40 extends from a point adjacent to drive pulley 38 to a clamp member 149 that is fastened to the lower portion of an inside wall 45 of the van, at the forward end of the wheel well thereof, and securely holds the forward end of flexible sheath 40 thereto. Sheath 40 protects and guides a lower cable member 41 as the cable member extends around the

wheel well between drive pulley 38 and an idler pulley 152. One end of cable member 41 is anchored on drive pulley 38. The other end of cable member 41 passes around idler pulley 152 and proceeds through the lower guide member 24, over a wear strip 46 therein, to an anchor point (not shown) on the forward lower bracket 22 of door 12, adjacent to roller 23.

An upper flexible sheath or conduit 43 extends from a point adjacent to drive pulley 38 to clamp 148 that is fastened to a mid-level location on the inside wall 45 of the van, adjacent to the rear edge of door 12, at a vertical height corresponding to the height of the rear guide member 31. Clamp 148 securely holds the forward end of flexible sheath 43 to the wall 45 and protects and guides an upper cable member 42 as the cable member extends along the inside wall of the van, between drive pulley 38 and an idler pulley 48 about which it is entrained. One end of cable member 42 is anchored on drive pulley 38. The cable member 42 passes through sheath 43, around idler pulley 48, over a wear strip 47 at the forward end of rear guide member 31, and along the rear guide member 31 (FIG. 7), through a grommited opening 49 in link 29 of the rear bracket and roller assembly 26, and has its other end anchored on link 29 by screw clamps 7 8 and 9.

As shown in FIGS. 10 and 11, the drive pulley 38 has two separate grooves 65, 66 therein which are interconnected by an axially directed opening or passageway 67. The lower cable member 41 spirally winds and unwinds from groove 65, and the upper cable member 42 spirally winds and unwinds from the groove 66, when drive pulley 38 rotates in connection with opening and closing the sliding van door 12. In the embodiment shown, the cable members 41 and 42 are separate portions of one continuous cable. Thus, the spirally inner ends of the cable members 41 and 42 on pulley 38 interconnect with one another by a short length of cable 68 that passes through the axial opening 67 of the pulley so that during initial installation, the relative lengths of the upper and lower cable members can be suitably adjusted by drawing an appropriate length of cable through the opening. Alternatively, the spirally inner ends of cable members 41 and 42 could, of course, be separate from one another and individually clamped to the inner portions of the grooves 65 and 66.

Referring to FIGS. 6 and 8 in conjunction with FIGS. 10 and 11, when the motor 2M rotates pulley 38 in the direction shown by an arrow on pulley 38 in FIG. cable member 42 spirally winds onto pulley 38, within groove 66, shortening cable 42, while cable member 41 spirally unwinds from pulley 38, paying out of groove 65 and lengthening. The result of such lengthening of cable member 41 and shortening of cable member 42 is that sliding door 12 is pulled along its tracks 17, 24 and 31 from its open position toward its closed position by cable member 42 while cable member 41 lengthen to accommodate the closing movement of the door. Conversely, in a door opening movement, motor 2M rotates drive pulley 38 in a direction opposite to that shown by the arrow on pulley 38 in FIG. 10, causing lower cable member 41 to shorten and pull door 12 from its closed position to its open position, while upper cable member 42 pays out to accommodate such movement. In this manner the sliding door 12 may be moved through various of its opening and closing movements, depending on the direction of rotation of motor 2M.

As best seen in FIG. 6, the idler pulley 152 is fastened to the lower portion of inside wall 45 of the van adja-

cent to the rear of lower guide member 24 (at the inner rocker panel) by a bolt 153. Bolt 153 acts as the rotational axis and attachment point for an idler pulley 139, about which an electrical cord or cable 136 proceeds on its way from a spring reel 137 and an idler roll 138 to the interior of door 12. Electrical cord 136 passes through the lower guide member 24 to a clamp 154 on bracket 22 and then into the interior of door 12 via an aperture 155. The function of the electrical cable 136 will become more apparent hereinafter when the electrical components of the door operating system are discussed in greater detail, it being sufficient to note at this time that the cable 136 winds and unwinds from the reel 137 concurrently with the opening and closing movements of the door 12.

Referring to FIGS. 2-6 and 8, and as indicated earlier herein, motor 2M and drive pulley 38 are mounted on a tensioning slide assembly 34 that is slidably movable in slide 37 supported from the vehicle sidewall 20 by brackets 36. Motor 2M is fastened to the tensioning slide assembly 34 via bolts (not shown) so that the motor 2M and its drive pulley 38 are movable in a fore and aft direction relative to the guide 37, which is fixed to the inside of vehicle side wall 20. As described earlier herein, cable members 41 and 42 wind and unwind on drive pulley 38 when motor 2M is rotated and this causes the door 12 to go through its opening and closing movements. As the door 12 is moving parallel to the vehicle body during closing, a guide pin 61 (FIG. 2) carried at the forward end of the door 12 moves into a conical recess (not shown) in a body member 59 which forms a forward end of the door opening 19. As shown in FIGS. 4 and 5, at about the time that the pin 61 engages the conical recess in the door frame 59, the rear of the door begins a generally inward movement. At this point, the motion of the door becomes complex and the lower cable member 41 does not pay out from drive pulley 38 at the same rate as upper cable member 42 is wound onto drive pulley 38. In order to accommodate and compensate for the different length requirements of the two cables during this final closing movement of the door, the slide 34 (FIG. 6) is free to move in guide 37 under the influence of a spring 33 that is connected via a cable 150 and an idler pulley 151 to the tensioning slide assembly 34. The movement of tensioning slide assembly 34 in guide 37 allows the lengths of the cable members 41 and 42 to change while tension is maintained to keep the cable members on the drive pulley 38, the turning pulley 48 and the idler pulley 152, during both the initial opening and the final closing movements of the door. Spring 33 maintains the needed tension during such movements of the door.

Another function of the spring 33 and tensioning slide assembly 34 is to provide a means of avoiding personal injury to passengers and/or avoiding damage to the door drive means due to any obstruction that may be positioned between the door and the vehicle body during closing movements. In the event of such an obstruction motor 2M overpowers tension spring 33, causing slide assembly 34 to move forward beyond its normal travel limit. Accordingly, a camming plate 32 which is fastened to and carried by the tensioning slide assembly 34 will encounter and trip a limit switch 7LS, mounted at the forward end of guide 37, during its movement forward on guide 37 to signal that an obstruction has taken place. The direction of rotation of motor 2M and the direction of movement of door 12 is immediately reversed and the door then travels to its fully open

position until it is reactivated by pushbuttons in the electrical control system. Details of the manner in which the electrical circuits reverse the direction of rotation of drive motor 2M will be discussed hereinafter in connection with a description of the electrical controls for the van door operating system.

Referring to FIG. 6, with the door 12 in the closed position, the arm 22 of forward lower bracket and roller assembly 21 is positioned at its most forward and inward position on lower guide member 24. The lower cable member 41 thus lays against the guide member 24 and, as motor 2M begins to open the door, the cable member 41 pulls arm 22 rearwardly. At this time the lower cable member 41 is in contact with and rubs against lower guide member 24. Accordingly, the outer face or contact area of the guide member 24 is covered with a friction reducing wear strip 46 of, for example, teflon to prevent wear of both the cable member and the guide member. Once the door is approximately one-quarter of the way open, the cable is in free air within the lower guide member 24 from the arm 22 of the lower bracket and roller assembly 21 to the idler pulley 152. The cable is then smoothly guided via the flexible lower sheath or conduit 40 to drive pulley 38, where it is actively wound by motor 2M. Frictional wear of the lower cable member 41 during door closing is less of a problem in that the cable member 41 is being passively unwound from the drive pulley 38 as the door is moved forward toward its closed position by the upper cable member 42.

As best seen in FIG. 8, it is evident that the upper cable member 42 is in contact with the forward portion of guide member 31 during the full range of opening and closing movement of door 12. During door closing, the upper cable member 42 is being actively wound on drive pulley 38 by motor 2M. Conversely during door opening, the cable member 42 is passively being unwound from the drive pulley. As in the case of the lower guide member 24, wear and friction could present a problem here also. Accordingly, a friction reducing wear strip 47 of, for example, teflon is provided on the outer face of the rear guide member 31.

It should be noted that movement of the upper cable member 42 around guide member 31 and toward turning pulley 48 is generally inwardly of the door opening 19, and this movement carries bracket and roller assembly 26 and the rear end of door 12 along with it. Consequently, during the final closing movement of door 12, the upper cable member 42 imparts a low momentum closing force to the door which is directed generally inward. The inward movement of the rear end of the door 12, in turn, is accompanied by an engagement and latching of the latch bolt member 60 (FIGS. 2 and 17) carried by the rear end of the door with the striker pin 105 carried by the vehicle body member 45, preparatory to final closing or clamping of the door against the weather seal strip on the door frame, which action will be further described and illustrated in detail hereinafter. It should also be noted that when motor 2M is de-energized and the latch bolt member 60 and striker pin 105 are not in latched engagement, the door 12 may be freely moved manually between its nearly closed position and its fully open position since the motor 2M and cable members 41 and 42 add little frictional resistance opposing such movement, and since no provision is made to lock the drive pulley 38 in place when the motor is deenergized.

As most clearly shown in FIGS. 2, 8 and 9, door 12 is provided with handles 50 and 51 which when pulled to the rear (to the right as viewed in FIG. 8) move a pull rod 71 upward, a pivot plate 70 clockwise and a pull rod 57 forward. The forward movement of pull rod 57 can also be initiated by an electrical solenoid SOL, the armature of which is carried at the forward end of a pull rod 52. A link 53, which is pivoted to the door at 54 and is pivotally connected to rod 57 at pivot 56, is rotated about its pivot point 54 when rod 52 moves forward upon actuation of solenoid SOL. The forward movement of rod 52 causes rod 57 also to move forwardly due to the pivot connection 56 between rod 57 and link 53. Rod 57, in turn, is connected to the latch bolt mechanism of the door, shown generally at 60 in FIG. 2. Accordingly, when either of the handles 50 and 51 is pulled to the rear, or when the solenoid SOL is energized, the pull rod 57 is moved to the left as viewed in FIG. 8, causing the latch bolt mechanism 60 to become unlatched, as will appear in greater detail hereinafter, allowing the door to be either manually or automatically opened. The movement of pull rod 57 to its forward or unlatching position is sensed by a limit switch 5LS, which is actuated by link 53, and the limit switch, in turn, provides a signal to the electrical circuits that the door handle has been manually or electrically opened. The opening movement of the door handle also opens a forward latch member 58 which engages a suitable latch receiving member (not shown) in the vehicle body member 59 at the forward end of the door opening 19. The door handles 50 and 51 are located in respective recesses 62 and 63 (FIG. 9) of the door.

As will appear in greater detail hereinafter, push buttons 1PB, 2PB, 3PB and 4PB are employed in initiating movement of the door 12 amongst its various positions. Push buttons 1PB and 2PB (FIG. 9) are positioned in the door recesses 62 and 63, respectively, and are employed in signalling the electrical circuits, from the location of door 12, to move the door from its open position to its nearly closed position. Push buttons 3PB and 4PB (FIG. 1) are positioned adjacent to the vehicle driver's seat. Push button 3PB is employed in connection with opening door 12, and push button 4PB is employed in connection with closing door 12, from the vehicle driver's location.

Various of the positions of door 12 relative to the door opening 19 are sensed by limit switches that are mechanically carried on upper forward guide member 17 and are electrically connected into the electrical control circuits of the door operating system. Thus, referring to FIG. 8, a limit switch 6LS is carried at the rear end of guide member 17 and is actuated when the door is at its fully open position; and a limit switch 3LS is carried at an intermediate position, near the forward end of guide member 17, and is actuated when the door reaches its intermediate position, a point about two inches upstream of its nearly closed position. The arrival of the door at its nearly closed position is sensed by a limit switch 4LS (FIGS. 17 and 18) which is actuated when the latch bolt member 60 latches onto the striker pin 105. Referring to FIGS. 12A and 12B, limit switch 3LS is mounted outboard of guide member 17 and is provided with a curved, rockable, actuator arm 75 that extends through a slot 76 in an outer wall 77 of the guide member 17 to the interior thereof. Rockable arm 75 is contacted and actuated by the roller 16 of the upper forward bracket 15 of door 12 when the roller passes thereover. The arrangement is such that any out-

wardly directed forces exerted by roller 16 as it passes by limit switch 3LS are taken up by the portion of the outer wall 77 surrounding slot 76 in the guide member, while rocker arm 75 moves within slot 76 and actuates and deactuates the limit switch as roller 16 passes over it during the opening and closing movements of the door.

Referring now to FIGS. 2, 8 and 13-19, a final closing device or clamping mechanism, shown generally at 80, is provided for moving the door 12 from its nearly closed position, at which the latch bolt member 60 latches on to the striker pin 105, to a fully closed position, at which the weather seal strip of the door is compressed, and the door is fully into the door opening and flush with the side wall 20. The final closing device 80 includes a motor IM having an output shaft 81 on which an enlarged shaft extension or striker shaft 82 is mounted and keyed thereto for rotation therewith. The striker shaft 82 is machined adjacent one end of its outer surface to provide a ratchet tooth 83 having a radially extending face 84. The radially inner and outer ends of the face 84 are connected by a smooth spiral cam surface 85.

The forward end of the outer surface of striker shaft 82 also has a groove 86 machined therein so that a protruding cam surface 87 is provided relative to groove 86 at the outer surface of striker shaft 82. The striker shaft 82 rotates within a bronze bushing 88 that is press fit into an outer housing 89. A thrust washer 90 seats against the rear (right hand as viewed in FIG. 13) end of the bushing 88 in a stepped recess 89a of the housing 89. Washer 90 separates the end of the bushing from a collar or shoulder 91 formed at the rear (right hand as viewed in FIG. 13) end of striker shaft 82.

A bracket plate 92 is utilized to join the motor IM to the housing 89. Bracket 92 has an opening 93 therein through which the collar 91 freely passes so that the striker shaft 82 abuts against a shoulder 94 on motor shaft 81. The bracket 92 includes a plurality of small bolt holes 95 which align with corresponding threaded holes (not shown) on the back surface of housing 89 to allow the bracket 92 to be rigidly fastened to the rear end of the housing 89 by bolts (not shown). Similarly, the bracket 92 is provided with a plurality of large bolt holes 96 which are in alignment with corresponding threaded bolt holes 97 at the forward end of motor IM. Bolts (not shown) are employed to fasten the motor IM to the opposite side of bracket 92 from the housing 89 so that the various parts of the final closing device 80 are firmly joined together.

A pair of limit switches ILS and 2LS threadedly engage the housing 89 in corresponding threaded openings 98 and 99 thereof. The openings 98 and 99 are aligned with corresponding openings 98a and 99a in bushing 88 so that actuators 100 and 101 of the respective limit switches 1LS and 2LS ride in the groove 86 of striker shaft 82 and are actuated by the protruding cam surface 87 during rotation of the striker shaft 82, as will appear in greater detail hereinafter.

A pawl 102, a spring 103 and a lockbolt 104 are carried in an aperture 104a in housing 89. The aperture 104a is aligned with an aperture 104b in bushing 88 so that the pawl 102 is spring loaded downwardly into engagement with the spiral cam surface 85 on the outer surface of striker shaft 82. During clockwise rotation of striker shaft 82 (as viewed in FIG. 13), the pawl 102 rides up the spiral cam surface 85 until it reaches the top of the tooth 83 and then it drops down into engagement

with the radial face 84 of the tooth. This point represents the fully closed or clamping position of the final closing device 80. It is shown in FIG. 15 and it coincides with the actuation of limit switch 2LS by cam 87. The unclamped or open position of the final closing device 80 is illustrated in FIG. 14. It coincides with the actuation of limit switch ILS by cam 87.

The final closing device 80 is provided with a striker pin 105 which projects axially outwardly from an end surface 106 of the striker shaft 82. The end surface 106 constitutes a striker plate on which the striker pin 105 is eccentrically supported relative to the rotary axis of the shaft extension 82. The end of the striker pin 105 remote from surface 106 is provided with a flange or enlarged head portion 107 thereon for crash worthiness purposes. Preferably, the flange 107 is capable of preventing the latch bolt mechanism 60 on door 12 from axially pulling off of the striker pin during high impact axial loads of at least 3000 lbs. that might occur in an automobile accident.

The end of housing 89 remote from motor IM is provided with a reduced diameter threaded end portion 108 that is threadedly engaged by mounting nut 109. The end portion 108 is passed through one side of a corresponding opening in the rear body member 45 of the door opening and is bolted thereto by tightly threading the mounting nut 109 onto it from the other side of the body member. A key and slot arrangement (not shown) may be provided to insure that the clamping mechanism housing 89 does not rotate relative to frame member 45.

Referring to FIGS. 14-16, the various components 82-85 and 102-104 cooperate to form a unidirectional lock, shown generally at 110. The unidirectional lock 110 serves to prevent reverse rotation or back-driving of the striker pin 105 in the event that the fully closed door is impacted from the inside under high loads, for example a 2500 lb. striker pin crash worthiness side load established by governmental agencies and automobile manufacturers. As shown in FIG. 14, the striker pin 105 is extended to its fully open or unclamped position, awaiting both the arrival of the latch bolt mechanism 60 (FIG. 8) and the movement of the latch bolt mechanism to its latched condition prior to undergoing rotary motion which retracts the striker pin and moves the door to its fully closed, clamped position. This extended condition of striker pin 105 is also represented in FIGS. 17 and 18, wherein the latch bolt mechanism 60 is shown in its unlatched condition and about to engage the striker pin 105 in FIG. 17, and wherein the latch bolt mechanism 60 is shown in its latched condition in full engagement with striker pin 105 in FIG. 18. When the latch bolt mechanism 60 fully engages and latches on to striker pin 105, it actuates a limit switch 4LS which signals the electrical control system that the latch bolt mechanism 60 is fully latched on to the striker pin 105 and the electrical circuits, in turn, cause motor 1M to drive the striker pin 105 from its dotted line extended position, shown in FIG. 19, to its solid line, retracted, position shown in FIG. 19. This movement is occasioned by movement of the door 12 to its fully closed position, in which the door compresses the weather seal strip, shown generally at 115, against the vehicle body members constituting the frame of the door opening 19. It is also occasioned by clockwise rotation of the striker shaft 82 from the position shown in FIG. 14 to the position shown in FIG. 15, at which latter position the pawl 102 has dropped into place behind the ratchet

tooth 83 and is abutted by the face 84 of the ratchet tooth. In this position should the fully closed door be impacted from the inside under a high load, for example during a vehicle crash, the unidirectional lock 110 will, by virtue of its pawl 102 being in face to face confronting engagement with the face 84 of ratchet wheel tooth 83, resist reverse rotation or back driving of the striker pin 105 to prevent accidental, unintended opening of the door. As shown in FIG. 16, the striker pin is being moved from its retracted position to its extended position by clockwise rotation of the shaft 82. This rotation is initiated by the electrical circuits of the powered door operating system after a door opening cycle has been initiated by the operator and the latch bolt mechanism 60 has cleared the striker pin 105, as will appear in greater detail hereinafter.

Referring now to FIG. 20, which comprises a circuit diagram of the electrical control system utilized in controlling the operation of the powered sliding door operating system, a line numbering system has been employed to facilitate the description of the electrical system. The line numbers have been listed on the left side of FIG. 20 and they run consecutively from line No. 101 through line No. 119. The line numbers on which the contacts of relays appear have been listed to the right of the relays that control them, and normally closed contacts are indicated by underlining in the listings. Thus, referring to FIG. 20, relay 3CR (line 103) is provided with two sets of contacts, a normally open set of contacts in line 114 and a normally closed set of contacts in line 115.

Twelve volt DC voltage is brought in directly from the automobile battery (not shown) to the electrical control system of the powered sliding door operating system via a fuse F1 and a conductor 130. Twelve volt DC voltage is also brought in to the electrical control system through a transmission lever switch (not shown) via a fuse F2 and a conductor 131. The conductor 131 is energized only when the transmission lever is in either the park or neutral position. A conductor 132 is connected to the grounded side of the battery to complete the circuit across the electrical control system.

TABLE I below lists and describes the functions of the various push buttons, limit switches, solenoids and motors that are used in the electrical control system circuits in controlling the powered sliding door operating system. The table is added at this point to provide a convenient reference list for these components.

TABLE I

DESCRIPTION OF COMPONENTS	
Components	Description
1LS	Normally closed-opens when striker pin rotates to fully extended (unclamped) position
2LS	Normally closed-opens when striker pin rotates into its retracted (clamped) position.
3LS	Open when the door is forward of its intermediate position, and closed when the door is rearward of its intermediate position.
4LS	Normally closed-opens when latch member moves to fully closed (latched) position.
5LS	Normally open-closes when door handle is pulled open or when solenoid SOL is energized.
6LS	Normally closed-opens when door reaches fully open position.
7LS	Normally open-closes when door meets an obstruction during its closing movement.

TABLE I-continued

DESCRIPTION OF COMPONENTS	
Components	Description
1PB	Normally open-manually closed to close door from outside of vehicle.
2PB	Normally open-manually closed to close door from inside rear of van.
3PB	Normally open-manually closed by operator of vehicle to open door from the driver's station.
4PB	Normally open-manually closed by operator to close sliding door from the driver's station.
SOL	A solenoid connected to the door opening mechanism for unlatching the latch bolt mechanism and holding the latch bolt mechanism open, while energized.
1M	Motor for moving the striker pin between its extended and retracted position to move the door from its unclamped position to its clamped position.
2M	Motor for moving the door between its fully open and nearly closed positions.

Referring to FIG. 20 in conjunction with FIGS. 6 and 8, the electrical circuits of the powered sliding door operating system are shown in the condition they assume when the door is in its fully closed, fully clamped condition. Starting from this condition, a full door opening and then a full door closing cycle will be considered.

With the door in the fully closed and clamped position, the operator manually actuates the door handle 50, closing limit switch 5LS (line 106), or presses push button 3PB (line 105). Accordingly, control relay 4CR (line 105) energizes closing its contacts in line 108 and control relay 5CR (line 106) energizes, closing its contacts in line 119. The closing of contact 4CR in line 108 preconditions control relay 6CR for subsequent energization when control relay 2CR energizes, and the closing of contacts 5CR in line 119 causes solenoid SOL to energize to mechanically hold the door handle 50 in the open position, retaining limit switch 5LS in its actuated condition and retaining its contacts 5LS in line 106 closed. The opening of the door handle 50 and energization of solenoid SOL cause the latch bolt mechanism 60 to unlatch which, in turn, causes limit switch 4LS (FIG. 17) to deactuate, closing its contacts 4LS in line 102. It should be noted at this time that the unlatching of the latch bolt mechanism frees the door to move from its clamped position, or fully closed position, to its unclamped position, or nearly closed position, due both to the resulting expansion of the compressed weather seal strip and to the door opening movement initiated via motor 2M, as described below.

The closing of contacts 4LS in line 102 causes control relay 2CR (line 102) to energize, opening its contacts 2CR in line 104 and closing its contacts 2CR in lines 103 and 108. The closing of contacts 2CR in line 103 and the opening of contacts 2CR in line 104 are without further effect at this time. The closing of contacts 2CR in line 108 causes control relay 6CR (line 108) to energize through the now closed contacts 4CR in line 108. Accordingly, contacts 6CR in line 109 close, bypassing the contacts of relay 4CR in line 108; contacts 6CR in line 110 open, without further effect at this time; and, the two sets of contacts 6CR in line 117 close, energizing motor 2M (line 116) to start driving the door from its fully or nearly closed position toward its fully open position.

As the door moves away from its nearly closed position to its intermediate position, limit switch 3LS actuates and its contacts 3LS (line 101) close, energizing relay 1CR (line 101). Accordingly, contacts 1CR in line 103 close, energizing control relay 3CR (line 103) through the now closed contacts 2CR in line 103; contacts 1CR in line 104 open, without further effect at this time; contacts 1CR in line 106 open, de-energizing control relay 5CR (line 106); and, contacts 1CR in line 113 close, without further effect at this time. The de-energization of control relay 5CR (line 106) opens contacts 5CR in line 119, deenergizing solenoid SOL (line 119). Accordingly, the door handle resumes its unpulled condition and contacts 5LS (line 106) open, de-energizing control relay 4CR without further effect (since contacts 4CR in line 108 open but are bypassed by contacts 6CR in line 109).

The aforesaid energization of control relay 3CR (line 103), due to the closing of contacts 1CR in line 103 while contacts 2CR in line 103 were closed, causes contacts 3CR in line 114 to close and contacts 3CR in line 115 to open. Accordingly, motor 1M (line 114) becomes energized and starts rotating the striker pin 105 from its retracted position toward its fully extended position. During the rotation of motor 1M, limit switch contacts 2LS (line 104) close as the striker pin starts rotating out of its retracted position, but this is without further effect since relay 2CR is energized and its contacts in line 104 are open at this time. When the striker pin rotates to its fully extended (unclamped) position, limit switch contacts 1LS (line 103) open, de-energizing control relay 3CR (line 103). With the de-energization of control relay 3CR (line 103), its contacts 3CR in line 114 open and its contacts 3CR in line 115 close. Accordingly, the input side of motor 1M is de-energized and grounded, braking the motor and stopping the movement of the striker pin 105 with the striker pin in its extended (unclamped) position.

With the continuing opening movement of the door, the door eventually arrives at its fully open position at which time limit switch 6LS actuates, opening contacts 6LS in line 108 to de-energize control relay 6CR (line 108). Accordingly, the two sets of normally open contacts 6CR in line 117 open, deenergizing motor 2M, the normally open contacts 6CR in line 109 open without further effect, and the normally closed contacts 6CR in line 110 close without further effect, but preconditioning line 111 for subsequent closing operations. The door thus is now in its fully open condition, with the latch bolt mechanism 60 unlatched and with the clamping mechanism 80 open, or unclamped, ready for a door closing cycle to be initiated.

To initiate that portion of the door closing cycle which moves the door from its fully open position to its intermediate position, one or another of the push buttons 1PB (line 110), 2PB (line 111) or 4PB (line 112) is depressed. Push buttons 1PB and 2PB are physically located adjacent to the door handle 50, while push button 4PB is controlled by the driver of the vehicle at the driver's location. When any one of push buttons 1PB (line 110), 2PB (line 111) or 4PB (line 112) is depressed, their corresponding contacts close, energizing control relay 7CR (line 110). Accordingly, contacts 7CR in line 113 close, locking relay 7CR in an energized condition independently of the push button contacts in lines 110, 111, and 112, since contacts 1CR in line 113 are closed at this time. In addition, the two sets of normally open contacts 7CR in line 118 close with the energization of

relay 7CR to energize motor 2M with a polarity that causes the motor to drive the door in a closing direction, from its fully open position toward its intermediate position.

The initial closing movement of the door from its fully open position toward its intermediate position results in the limit switch 6LS deactuating, causing its contacts 6LS in line 108 to close without further effect since contacts 4CR and 6CR in lines 108 and 109, respectively, are open at this time. The door thus continues to move toward its intermediate position and, upon arrival at the intermediate position, limit switch 3LS (line 101) opens, de-energizing control relay 1CR (line 101), causing its contacts in line 103 and line 113 to open and its contacts in line 104 and line 106 to close. The opening of contacts 1CR in line 103 is without further effect since the contacts of limit switch ILS in that line are already open. The closing of contacts 1CR in line 104 is without further effect since the contacts of relay 2CR in that line are open at this time. The opening of contacts 1CR in line 106 is without further effect since push button 3PB (line 105), limit switch 5LS (line 106) and limit switch 7LS (line 107) are all open at this time. The opening of contacts 1CR in line 113 de-energizes control relay 7CR (line 110) and opens its contacts 7CR in line 113 without further effect and opens its two sets of contacts 7CR in line 118. The opening of the two sets of contacts 7CR in line 118 de-energizes the motor 2M, stopping the door at the intermediate position.

Accordingly, the door arrives at its intermediate position and the electrical circuits assume a common condition, awaiting further closing signals at that position. At this time, further closing movement of the door under the control of any of the push buttons 1PB, 2PB or 4PB requires the respective button to be maintained in its depressed condition to continue moving the door toward its fully closed position. This is due to the fact that control relay 1CR (line 101) is de-energized and its contacts 1CR in line 113 are open, preventing energization of relay 7CR through any path other than through the closing of contacts 1PB (line 110), 2PB (line 111) or 4PB (line 112).

Assuming that one or another of push buttons 1PB, 2PB or 4PB is depressed to continue the closing movement of the door from its intermediate position towards its nearly closed position, control relay 7CR (line 110) energizes and, in turn, energizes motor 2M via its two sets of contacts 7CR in line 118. Accordingly, while the selected push button 1PB, 2PB or 4PB is being depressed, the door continues to move toward its nearly closed position. The continued movement of the door causes the latch bolt mechanism 60 to engage and then latch onto the extended striker pin 105 of the clamping mechanism 80. Accordingly, limit switch 4LS (line 102) actuates, opening its contacts in line 102 and de-energizing control relay 2CR (line 102). As a result of this, contacts 2CR in line 103 close without further effect and contacts 2CR in line 108 open, deenergizing relay 7CR (line 110). Accordingly, the two sets of contacts 7CR in line 118 open, stopping the motor 2M with the door located between its nearly closed and fully closed positions. In addition the aforesaid de-energization of control relay 2CR (line 102) causes its contacts 2CR in line 104 to close, energizing control relay 3CR (line 103) through the now closed contacts 1CR and 2LS in line 104. The energization of control relay 3CR (line 103) causes its normally open contacts in line 114 to close and its normally closed contacts in line 115 to

open. Accordingly, motor 1M becomes energized and starts driving the striker pin 105 of the clamping mechanism 80 from its extended position to its retracted position, thereby moving the door from its unclamped condition to its fully clamped position.

The initial movement of the striker pin 105 from its extended position toward its retracted position causes the contacts of limit switch ILS in line 103 to close without further effect since contacts 1CR in line 103 are open at this time. When the striker pin reaches its fully retracted position, and the door is in its fully clamped condition, the limit switch contacts 2LS of line 104 open, de-energizing control relay 3CR (line 103). Accordingly, contacts 3CR of line 114 open and contacts 3CR of line 115 close, grounding the input to motor 1M of line 114 and causing the motor to brake to a stop with the striker pin in its fully retracted position and the door fully clamped. At this point the door is fully closed and the electrical circuits are back to the condition they were in when this description of a complete opening and closing cycle of the door was started.

At any time during the closing of the sliding door, safety limit switch 7LS can be actuated. This safety feature will sense if an object or body portion is obstructing the closing of the door and, if so, the contacts 7LS on line 107 will close, energizing control relay 4CR on line 105. Contacts 4CR (line 108) thus close, energizing control relay 6CR on line 108, causing its contacts 6CR on line 110 to open and immediately de-energize control relay 7CR on line 110. This near immediate action of control relay 6CR energizing and control relay 7CR de-energizing opens two sets of contacts 7CR on line 118 and closes two sets of contacts 6CR on line 117, which reverses the polarity to motor 2M. The aforesaid energization of control relay 6CR (line 108) also causes contacts 6CR on line 109 to close, by-passing the contacts of relay 4CR on line 108. The aforesaid de-energization of control relay 7CR (line 110) also causes contacts 7CR on line 113 to open without further effect. Once the door has been obstructed, limit switch 7LS has actuated and the door movement has reversed, the door will continue to open as in a normal door opening operation.

Referring to FIGS. 6 and 8, and as indicated earlier herein, a multi-wire cable 136 is employed to interconnect the electrical components inside the door 12 (e.g., limit switches 4LS and 5LS, push buttons 1PB and 2PB, and solenoid SOL) with the remaining electrical components of FIG. 20. Cable 136 exits from the forward lower portion of the door 12 via an aperture 155 and is supported on the underside of arm 22 adjacent to roller 23 by a clamp 154. From the end of arm 22 it proceeds rearwardly along the lower forward guide member 24 parallel to lower cable member 40 and around idlers 139 and 138 to a spring driven take-up reel 137 on which it winds during opening movement of the door and from which it unwinds during closing movement of the door. An end portion 135 of cable 136 exits from the upper surface of the take-up reel 137 to connect the various wires of the cable 136 to their corresponding lines of the electrical control system of FIG. 20. The various control relays of the electrical control system, and the wires associated therewith, are preferably housed in an electrical cabinet, shown generally at 140. Reel 137 is so dimensioned that about 3 turns of the reel is sufficient to completely wind and unwind cable 136 therefrom during full opening and closing movements of the door. The end portion 135 of cable 136 is initially installed in

an untwisted condition with the door midway between its fully open and fully closed positions so that it only twists $1\frac{1}{2}$ turns in each direction during opening and closing of the door.

From the foregoing detailed description, it is apparent that the present invention provides an improved powered sliding door operator and powered sliding door operating system for van type vehicles. The sliding door is moved with low momentum by the powered sliding door operator from its fully open position to its nearly closed position, and vice versa, so as to reduce the safety hazards encountered in existing manual sliding doors and existing powered sliding door operators. In addition the powered sliding door operator system provides for the complete closing of the sliding door in a safe, slow, controlled manner, and the manual effort required to open and close the sliding door utilizing the foregoing powered sliding door operator and system is substantially reduced or eliminated. Moreover, in the event that the powered sliding door operator or system is not functional, due to a vehicle accident or a system failure or the like, it is apparent that the powered door operator and system of the present invention allows near-normal manual operation for opening and closing the sliding door, albeit that the manual closing operation requires the high momentum slamming movement of conventional sliding door closing arrangements. In addition, the present invention provides a powered sliding door operating system which can be actuated either from the vehicle driver's seat or from the sliding door itself.

While there has been shown and described what is presently considered to be the preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the broader aspects of this invention. It is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. A door operator for a slide door that is slidably supported relative to a door opening in a side panel of a vehicle body, said door being supported adjacent its forward end on at least one forward guide member and being supported adjacent its rear end on a rear guide member, said guide members guiding said door through an initial closing movement and a final opening movement generally parallel to said side panel, through at least a portion of its initial opening movement generally away from the plane of said door opening and through at least a portion of its final closing movement generally toward the plane of said door opening, said door operator comprising means including a first cable member coupled to the rear end of said door and a second cable member coupled to the forward end of said door for driving said door along said guide members to thereby move said door through said initial and final opening and closing movements, each of said cable members being supported substantially entirely within the interior of the vehicle body when the slide door is fully closed.

2. A door operator for a slide door that is slidably supported relative to a door opening in a side panel of a vehicle body, said door being supported adjacent its forward end on at least one curved forward guide member by a forward bracket and roller assembly and being supported adjacent its rear end on a curved rear guide member of a rear bracket and roller assembly, said

guide members guiding said door through an initial closing movement and a final opening movement generally parallel to said side panel, through at least a portion of its final closing movement generally toward the plane of said door opening and through at least a portion of its initial opening movement generally away from the plane of said door opening, said door operator comprising means including a first cable member coupled to said rear bracket and roller assembly for driving said rear bracket and roller assembly along said rear guide member to thereby move said door through said initial and final closing movements, said door operator means including a second cable member coupled to said forward bracket and roller assembly for driving said forward bracket and roller assembly along said forward guide member to thereby move said door through said initial and final opening movements.

3. A door operator for a slide door that is slidably supported relative to a door opening in a side panel of a vehicle body, said door being supported adjacent its forward end on at least one curved forward guide member by a forward bracket and roller assembly and being supported adjacent its rear end on a curved rear guide member by a rear bracket and roller assembly, said guide members guiding said door through an initial closing movement and a final opening movement generally parallel to said side panel, through at least a portion of its final closing movement generally toward the plane of said door opening and through at least a portion of its initial opening movement generally away from the plane of said door opening, said door operator comprising means including a first cable member movable in said curved rear guide member and coupled to said rear bracket and roller assembly for driving said rear bracket and roller assembly along said rear guide member to thereby move said door through said initial and final closing movements, said door operator means including a second cable member movable in said curved forward guide member and coupled to said forward bracket and roller assembly for driving said forward bracket and roller assembly along said forward guide member to thereby move said door through said initial and final opening movements.

4. A door operator for a slide door that is slidably supported relative to a door opening in a side panel of a vehicle body, said door being supported adjacent its forward end in at least one curved forward guide member by a forward bracket and roller assembly and being supported adjacent its rear end in a curved rear guide member by a rear bracket and roller assembly, said guide members guiding said door through an initial opening movement and a final closing movement generally parallel to said side panel, through at least a portion of its final opening movement generally away from the plane of said door opening and through at least a portion of its initial closing movement generally toward the plane of said door opening, said door operator comprising means including a first cable member coupled to the rear end of said door and a second cable member coupled to the forward end of said door for driving said bracket and roller assemblies along said guide members to thereby move said door through said initial and final opening and closing movements, each of said cable members being supported substantially entirely within the interior of the vehicle body when the slide door is fully closed.

5. A door operator according to any one of claims 2, 3 and 4, and further including motor means coupled to

said cable members for moving said door along said guide members.

6. A door operator according to claim 5, and further including a first pulley member rotatably supported within said vehicle body adjacent one end of said rear guide member, a second pulley member rotatably supported within said vehicle body adjacent one end of said forward guide member and a third pulley member driven by said motor means, and wherein said first and second cable members are entrained about corresponding ones of said first and second pulley members and are inversely anchored to said third pulley member so that rotation of said third pulley member causes one of said cable members to pay out while the other of said cable members winds up, said rear bracket and roller assembly being fixedly connected to said first cable member and said forward bracket and roller assembly being fixedly connected to said second cable member so that rotation of said motor means in one direction or another causes one or another of said bracket and roller assemblies to slidably move said door in one direction or another relative to said vehicle body.

7. A door operator according to any one of Claims 2, 3 and 4, wherein said sliding door includes a latch bolt member adjacent to its rear end that is movable between an unlatched position and a latched position upon engagement with a striker pin, and wherein said door operator further includes a first motor means coupled to said cable members for moving said slide door along a major portion of said guide members, between a fully open position and a nearly closed position that is closely adjacent to a fully closed position, and a second motor means carried by said vehicle body at the rear of said door opening and including an eccentrically mounted striker pin thereon engageable by said latch bolt member when said door is in its nearly closed position for moving said door from its nearly closed position to its fully closed position.

8. A door operator according to claim 7, and further including a first pulley member rotatably supported within said vehicle body adjacent one end of said rear guide member, a second pulley member rotatably supported within said vehicle body adjacent one end of said forward guide member and a third pulley member driven by said first motor means, and wherein said first and second cable members are entrained about corresponding ones of said first and second pulley members and are inversely anchored to said third pulley member so that rotation of said third pulley member causes one of said cable members to pay out while the other of said cable members winds up, said rear bracket and roller assembly being fixedly connected to said first cable member and said forward bracket and roller assembly being fixedly connected to said second cable member so that rotation of said first motor means in one direction causes said forward bracket and roller assembly to slidably move said door in one direction relative to said vehicle body, from its nearly closed position to its fully open position, and rotation of said first motor means in another direction causes said rear bracket and roller assembly to slidably move said door in another direction relative to said vehicle body, from its fully open position to its nearly closed position.

9. A door operating system for a door that is slidingly supported relative to a door opening in a side panel of a vehicle body, said door being supported adjacent its forward end on at least one forward guide member carried by said vehicle body and being supported adja-

cent its rear end on a rear guide member carried by said vehicle body, said guide members guiding said door through (i) an initial closing movement generally parallel to said side panel, (ii) a final opening movement generally parallel to said side panel, (iii) at least a portion of its final closing movement generally toward the plane of said door opening, and (iv) at least a portion of its initial opening movement generally away from the plane of said door opening, said door including a latch bolt member carried adjacent the rear end thereof and movable between latched and unlatched positions, said door operating system comprising drive means including a first cable member coupled to the rear end of said door and a second cable member coupled to the forward end of said door for moving said door along said guide members and through said initial and final opening and closing movements, and clamping means including a rotatable striker plate mounted on said vehicle body and having an eccentrically mounted striker pin thereon engageable by said latch bolt member of said door for clamping said door to said vehicle body with said door in a finally closed position in said door opening.

10. A door operating system according to claim 9, wherein said clamping means moves said door between an unclamped position thereof and a clamped position thereof, wherein said drive means moves said door between a fully open position and a nearly closed position and wherein said nearly closed position of said door corresponds to said unclamped position of said door.

11. A door operating system according to claim 10, wherein said clamping means further includes means for unidirectionally rotating said striker plate to move said striker pin between extended and retracted positions corresponding respectively to said unclamped and clamped positions of said door.

12. A door operating system according to claim 11, and further including circuit means connected to said drive means and to said clamping means for controlling operation of said door operating system, said circuit means including solenoid means coupled to said latch bolt member and operative, when energized, to move said latch bolt member from its latched position to its unlatched position for permitting said door to be moved from its clamped position to its unclamped position manually operable switch means coupled both to said solenoid means and to said drive means for energizing said solenoid means and said drive means thereby to move said door from its clamped position to its fully open position, and means responsive to the arrival of said door at its fully open position for de-energizing said drive means to stop said door at its fully opened position.

13. A door operating system according to claim 12, wherein said circuit means further includes means responsive to opening movement of said door and arrival of said door at a point intermediate its unclamped position and its fully open position for actuating said striker plate rotating means to move said striker pin from its retracted position to its extended position.

14. A door operating system according to claim 11, and further including circuit means connected to said drive means and to said clamping means for controlling operation of said door operating system, said circuit means including a plurality of manually operable switch means therein responsive to manual actuation when said door is between its open position and an intermediate position located between its fully open position and its

nearly closed position for energizing said drive means to move said door from said open position to said intermediate position, means responsive to the arrival of said door at said intermediate position for de-energizing said drive means, and means responsive to re-actuation of at least one of said manually operable switch means for moving said door from said intermediate position to said nearly closed position.

15. A door operating system according to claim 14, wherein said latch bolt member engages said striker pin and is moved to its latched position by said striker pin as said door approaches and moves into its nearly closed, unclamped position, and further including means responsive to the movement of said latch bolt member to its latched position and operative to energize said striker plate rotating means upon arrival of said latch bolt member at its latched position for moving said striker pin from its extended position to its retracted position thereby to move said door from its unclamped position to its clamped position.

16. A door operating system according to claim 15, further including switch means actuated upon arrival of said striker pin at its retracted position and operative to deenergize said striker plate rotating means for stopping the movement of said door at its clamped position.

17. A door operator for a slide door that is slidably supported relative to a door opening in a side panel of a vehicle body, said door being supported adjacent its forward end in at least one curved forward guide member by a forward bracket and roller assembly and being supported adjacent its rear end in a curved rear guide member by a rear bracket and roller assembly, said guide members guiding said door through an initial opening movement and a final closing movement generally parallel to said side panel, through at least a portion of its final opening movement generally away from the plane of said door opening and through at least a portion of its initial closing movement generally toward the plane of said door opening, said door operator comprising means including a first cable member coupled to the rear end of said door and a second cable member coupled to the forward end of said door for driving said bracket and roller assemblies along said guide members

to thereby move said door through said initial and final opening and closing movements, said sliding door further including a latch bolt member adjacent its rear end that is movable between an unlatched position and a latched position upon engagement with a striker pin, said door operator further including a first motor means coupled to said cable members for moving said slide door along a major portion of said guide members, between a fully open position and a nearly closed position that is closely adjacent to a fully closed position, and a second motor means carried by said vehicle body at the rear of said door opening and including an eccentrically mounted striker pin thereon engageable by said latch bolt member when said door is in its nearly closed position for moving said door from its nearly closed position to its fully closed position.

18. A door operator according to claim 17, and further including a first pulley member rotatably supported within said vehicle body adjacent one end of said rear guide member, a second pulley member rotatably supported within said vehicle body adjacent one end of said forward guide member and a third pulley member driven by said first motor means, and wherein said first and second cable members are entrained about corresponding ones of said first and second pulley members and are inversely anchored to said third pulley member so that rotation of said third pulley member causes one of said cable members to pay out while the other of said cable members winds up, said rear bracket and roller assembly being fixedly connected to said first cable member and said forward bracket and roller assembly being fixedly connected to said second cable member so that rotation of said first motor means in one direction causes said forward bracket and roller assembly to slidably move said door in one direction relative to said vehicle body, from its nearly closed position to its fully open position, and rotation of said first motor means in another direction causes said rear bracket and roller assembly to slidably move said door in another direction relative to said vehicle body, from its fully open position to its nearly closed position.

* * * * *

45

50

55

60

65